Estimated Interaction Background - 3

Preface

The interaction (scattering) background in the 203 event set is estimated from the Monte Carlo and the total path length in the target modules. The result is to be compared to results obtained by other analyses, with this analysis based on GEANT 3.21.

Method

The LEPTO/GEANT-based Monte Carlo is used to generate 10^4 ν_μ NC interactions, and subsequently propagate the created tracks through 1.0 mm of iron before being recorded as data. To facilitate analysis, all tracks with angles less than 0.3 rad were "collapsed" to p_x and $p_y = 0$ with z defining the neutrino direction. Thus, all tracks started in the iron along the z-axis, and the initial direction is not needed. Importantly, all charged tracks, which are generated from primary or secondary interactions, are included in this way, without any need to keep track of particle ID or history.

The estimated background is computed from the total weight from all entries (tracks) that pass the following cuts:

1. the initial primary track angle $\theta_{init} < 0.30$ rad
2. the scattering angle at the measurement point $\theta_{scat} < 0.30$ rad
3. the momentum at the measurement point $p > 1$ GeV/c
4. the final transverse momentum $p_T >$ (value set)

The weight after cuts is normalized (divided by) the total weight from all charged tracks in the sample without any cuts applied. This number should be close to the (raw) number of tracks that pass the above cuts, divided by the total number of tracks in the sample. This normalized value is the probability of scattering per track per mm of path length. The total path length in the 203 sample is estimated from the expected distribution of events in three module types: ECC200, ECC800, and bulk. The total path length is the linear distance that a single track would follow through all the iron plates in the experiment (assuming no sample bias) times the number of tracks that are part of the "NC-like" background subset in the 203 events. The product of this path length and the probability of scattering per mm is the estimated interaction background for a particular p_T cut.

Results

The results from the MC analysis are summarized in Table 2. The total weight for the MC sample (10^4 events) of charged tracks is 5.36×10^6, with a average weight of 132.1. This gives the mean number of tracks (weighted) per event as :

$$\langle N_{tracks} \rangle = \frac{5.36 \times 10^6}{132.1 \cdot 10^4} = 4.06$$

This is compared to the raw (unweighted) number of 4.01 tracks per event. Note that the effect of weighting the distributions, as seen by comparing the total number of tracks, is not large. This is to be expected in the transverse momentum distributions, which cannot be sensitive to the longitudinal component, except through second-order effects such as multiplicity (which is sensitive to momentum). The effect of the cuts 2 and 3 are shown in Table1, where cut 1 has already been applied to the output file.

Cut	wgt remain
1	1.00
2	0.35
3	0.22
4 $p_T = 0.25$	0.0012

Table 1. The effect of the cuts on the MC sample.

p_T cut(GeV/c)	no. tracks	wgt	wgt/wgt(tot)
0.	40100	5.36×10^{6}	1.00
0.05	107	16200.	3.0×10^{-3}
0.1	71	11100.	2.1×10^{-3}
0.2	49	7860.	1.5×10^{-3}
0.25	40	6660.	1.2×10^{-3}
0.3	32	5830.	0.9×10^{-3}

Table 2. The effect of applying the transverse momentum cut.

The probability of interaction for a track produced by NC interactions in passing through 1mm of iron is $1.2\pm0.2\times10^{-3}$. Note that the p_T cut is most effective below 0.1 GeV/c and the results imply that the rejection increases only by two between 0.1 and 0.25 GeV/c.

The total path length through iron is estimated by assuming the distribution of interactions in the set is not biased, so the probability of interaction in any module is proportional to its mass times POT. The fraction of events in ECC200 is calculated to be 0.31 and in ECC800, 0.36 (the remaining 0.33 in bulk). Assuming a 5mm maximum track length cut, and that the interaction vertex is uniformly distributed in the 1mm iron plate, and that the track does not leave the scan volume, the mean path length in iron is 3.4mm per track for ECC200 and 2.5mm in ECC800. Finally, the number of "NC-like" events needs to be estimated. There are 71 identified ν_μ CC interactions. From the energy distribution in the calorimeter, there are 61 ν_e CC interactions. Assuming 80% of these n_e CC interactions can be recognized individually, there are 203 - 71 - 43 = 89 events that cannot be eliminated and form the background set of tracks. Putting these numbers together:

$$N_{bkg}(ECC200) = 3.4mm \cdot 0.32 \cdot 89 = 97mm$$
$$N_{bkg}(ECC800) = 2.5mm \cdot 0.36 \cdot 89 = 80mm$$
$$\Sigma = 177mm$$

Then, the number of background scattering tracks is

$$N_{bkg}(Fe) = 1.2\times10^{-3}mm^{-1} \cdot 177mm = 0.21 \pm 0.04$$

Since this number is small compared to the total number of tracks, it also represents the number of events with a background track.

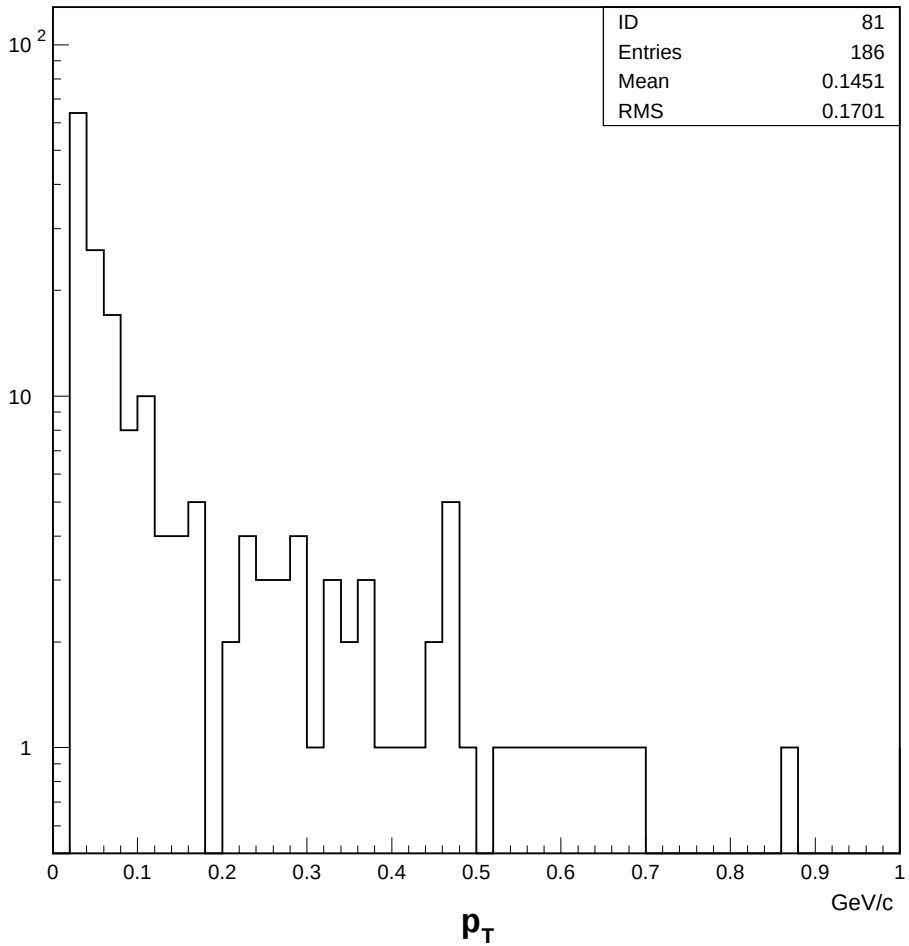

Figure 1. The transverse momentum distribution for the MC events in the sample after cuts 1 - 3. There is a 20 MeV/c p_T cut to eliminate the first bin for clarity.